ESOPHAGEAL GLANDS

The dorsal esophageal gland has a very short narrow duct lined with cuticle which is continuous with a protoplasmic central tubule having a thick deeply basophilic wall. This tubule becomes wider and bifurcates posterior to the orifice of the gland, each branch giving off numerous short branches which are continuous with the coarsely reticulate, deeply basophilic cytoplasm of the gland (Fig. 4a–b). In the anterior part of the precorpus the dorsal gland is rather wide and circumscribed, and occupies a central position in the dorsal sector. In the remainder of the corpus the dorsal gland is narrow (Fig. 4c) and the gland mass finely reticular to alveolate; it becomes a narrow strand in the region of the isthmus, and again larger in the anterior part of the bulbar region. Near the level of its nucleus, the dorsal gland becomes multilobed and occupies a large part of the dorsal sector; in this region the cytoplasm is dense and contains a few alveoli.

The subventral glands extend some distance anterior to their orifices; in this region the cytoplasm is very finely reticulate (Fig. 4d). Near the level of their orifices the subventral glands become multilobed but the finely reticular structure remains. Each gland has an extremely short duct lined with cuticle, and continuous with this duct is a thick-walled protoplasmic tube which is immediately multibranched, the branches continuous with the reticulum. Posterior to this region the gland mass, like the dorsal gland, becomes smaller until it is finally reduced to a delicate strand of protoplasm in the isthmian region. The subventral glands become enlarged in the posterior part of the prevalvar region, become lobed in the region of their nuclei, and then continue to be large and lobed nearly to the base of the esophagus. The protoplasm is dense throughout this region except in the part adjacent to the lumen. In general, the mass of the subventral glands is less basophilic than that of the dorsal, and sometimes appears to be very slightly eosinophilic.

ZOOLOGY.—*Development and morphology of the cestode,* Hymenolepis cantaniana, *in coleopteran and avian hosts.*[1] M. F. Jones and J. E. Alicata, Bureau of Animal Industry. (Communicated by Eloise B. Cram).

Previous to the preliminary note by Alicata and Jones[2] in 1933, the life history of the poultry cestode, *Hymenolepis cantaniana,* was unknown. There was reported at that time the finding, in the dung beetle *Ataenius cognatus,* of proliferating larvae which consisted of a mycelium-like structure, numerous buds, and partially or completely developed cysticercoids (Fig. 1). The larvae developed to maturity in chicks and were identified as *H. cantaniana.* The present paper gives a more detailed account of the development and morphology of the proliferating larva of this cestode in the intermediate host, *Ataenius cognatus.* Since the previous report, 2 additional beetles, *Ataenius stercorator* from Puerto Rico and *Choeridium histeroides* of local origin have been found to harbor similar proliferating larvae, presumably those of *H. cantaniana.* The larvae from *Ataenius stercorator* were collected by Dr. H. L. Van Volkenberg and sent to the Zoological Division for identification, with the statement in a personal communication that this material was identical with that which he reported, but did not describe in 1931.[3] In the present paper, geographical distribution and seasonal occurrence of the intermediate hosts are discussed briefly. A short description of the adult worm, with data regarding its development, subsequent to laboratory feedings, in the chicken, guinea fowl, and bobwhite quail, also are included.

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[1] Received March 12, 1935.

[2] Alicata, J. E., and Jones, M. F. *The dung beetle,* Ataenius cognatus, *as the intermediate host of* Hymenolepis cantaniana. Jour. Parasitol. 20: 244. 1933.

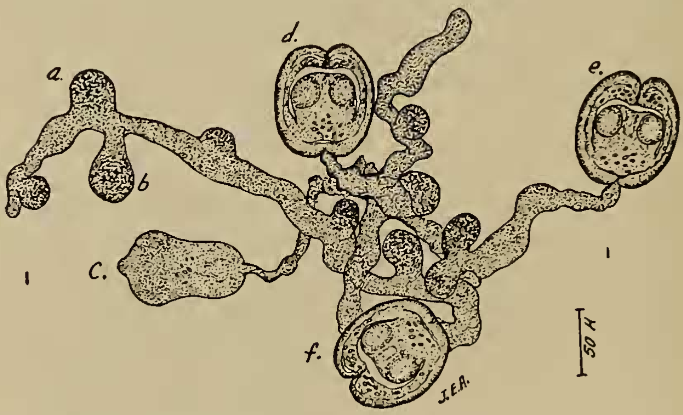

Fig. 1.—Larvae of *Hymenolepis cantaniana* from *Ataenius cognatus.* Natural infestation. *a, b, c,* developing cysticercoids; *d, e. f,* apparently mature cysticercoids still attached to branching larval tissue. After Alicata and Jones, 1933.

The authors wish to thank Dr. E. A. Chapin of the U. S. National Museum for identifying beetles and for supplying data regarding distribution of the 3 beetles reported as intermediate hosts.

SOURCE OF LARVAL MATERIAL

The greater part of the cestode larvae available for study occurred as natural infestations in numerous specimens of *Ataenius cognatus;* larvae were observed also in one specimen of *Choeridium histeroides.*

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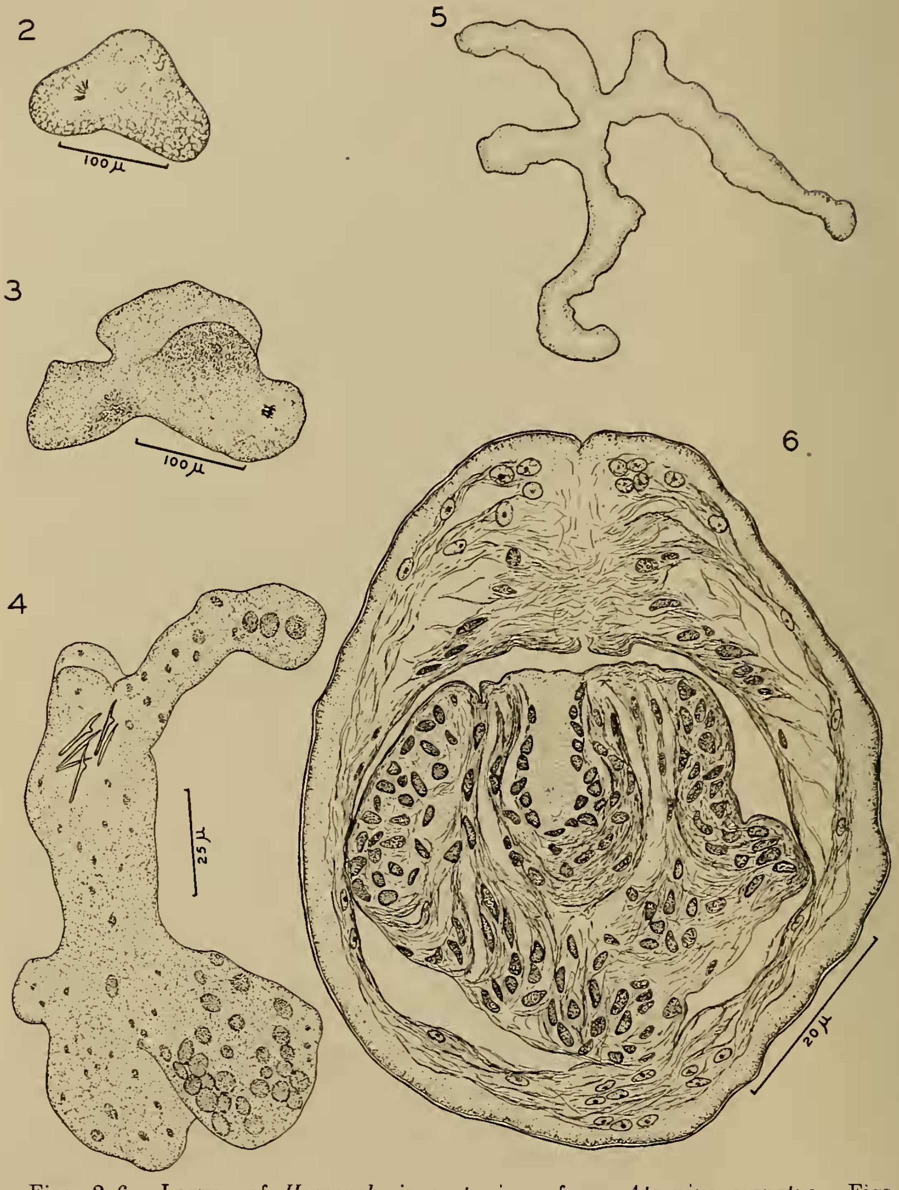
[3] Van Volkenberg, H. L. *Report of parasitologist.* Report Puerto Rico Agric. Exp. Sta. 1930: 38–40. 1931.

These beetles were collected in or near poultry yards, in particular at the Beltsville Research Center of the U. S. Department of Agriculture near Beltsville, Maryland. Three specimens of *Ataenius stercorator*, infested with proliferating larvae, were sent to the Zoological Division from Puerto Rico; the total number of infested beetles of this species, found in that locality by Van Volkenberg, is not known. No laboratory-reared beetles of any of these species were used. A few specimens of *A. cognatus*, after being kept in the laboratory for 2 weeks or longer after collection, were fed eggs of *H. cantaniana* and subsequently harbored young larvae in various stages of development. With one exception, the early stages of development described below were obtained from these experimentally infected beetles. Following experimental feeding, larvae were found in beetles after 24 hours (2 beetles), after 8 days (1 beetle), after 9 to 12 days (1 beetle, fed August 2, 4, and 5, and examined August 14), and after 11 to 14 days (1 beetle, fed August 2, 4, and 5, and examined August 16). A larva, less developed than those observed in the beetles fed 8 days previously, was found in a naturally infested beetle which also contained larvae of more advanced development, some of which exhibited completely formed cysticercoids.

Larvae were examined as fresh material and also as both stained and unstained permanent mounts. Two beetles were sectioned for observation of larvae *in situ*.

DEVELOPMENT OF LARVA IN INTERMEDIATE HOST

The youngest larvae of *H. cantaniana* observed were obtained from a beetle 24 hours after experimental infection; the identification of the larvae was based on the embryonal hooks which were 13 to 14μ long. One larva, observed soon after it was recovered from the body of a beetle, was slightly elongate and became rounded during observation; as unfixed material it was undifferentiated in appearance and disintegrated quickly. A similar elongate specimen measured 106μ long by 54μ wide. A third larva (Fig. 2) was trilobed, being about 160μ along its greatest axis; another larva (Fig. 3), more definitely lobed, measured about 200μ along its greatest axis. At least 6 small lobes or branches were exhibited by a smaller larva (Fig. 4) of unknown age which measured about 140μ along its greatest axis after having been mounted and stained with methylene blue. It is considered typical of early branching or proliferating larvae of this species; its nuclei are comparatively large and are definitely more concentrated near the tip of each branch. Apparently the first few branches elongate (Fig. 5)



Figs. 2–6.—Larvae of *Hymenolepis cantaniana* from *Ataenius cognatus*. Figs. 2–3.—Obtained 24 hours after experimental feeding. Fig. 4.—Young larva, natural infestation. Fig. 5.—Sketch of branching larva, 8 days after experimental feeding. Fig. 6.—Completely formed cysticercoid. Sectioned material.

before many new buds arise. A larva recovered from a beetle fed 8 days previously had a maximum axis length of 605μ and exhibited considerable proliferation, there being 4 distinct elongate branches and 2 rounded buds. Larvae from a beetle fed 9 to 12 days previously consisted of numerous branches and a few buds which represent partly developed cysticercoids. Larvae recovered from a beetle of the same lot fed 11 to 14 days previously consisted of numerous branches, buds, partly formed and completely formed cysticercoids, the latter representing the infective larvae proper.

To summarize briefly on the basis of observations on numerous larvae, the hexacanth embryo develops into lobes, then a branching, mycelium-like structure, the branches of which bear buds which may develop into new elongate branches or directly into cysticercoids. In general, on the branching larval stem, the development of a bud into a cysticercoid resembles the more commonly observed development of hexacanth embryo into cysticercoid of other species of tapeworms, except that the embryonal hooks of *H. cantaniana* remain in the basal stem, or are lost, and consequently are not involved in the development of bud into cysticercoid (Figs. 1, 7, 8). A larva early in its development, still somewhat globular except for the area of attachment to the stem, is about 35 to 50μ in diameter; the cell nuclei are closer together than are those of the proliferating stem itself. These globular structures, while remaining attached to the stem, elongate and become ovoid; with further elongation constrictions appear; the first constriction results in a larva made up of a smaller proximal region, nearer the stem, and a larger distal region (Fig. 1c). Such larvae, with one constriction, may be 70 to 85μ long by 35μ in diameter through the proximal region and about 40 to 45μ in diameter through the distal region. Cells of the distal region are the more concentrated; in the median and proximal regions the outer cells lie close together, but the inner cells have elongate projections and form a loose tissue which represents the "primitive cavity" of the developing cysticercoid. While the first constriction, mentioned above, is becoming more marked, there occurs cell differentiation in the distal region in 4 areas which represent the future suckers. At the distal tip, a few large cells are to be observed which later develop as a projection representing the future rostellum; at an early stage this projection is 10.5μ long by 7μ in diameter.

A second constriction appears proximal to the suckers, and differentiation progresses. The region of loose fibrous tissue becomes more marked, suckers become more distinct, and a narrow cavity appears in the projecting rostellum, the latter 22μ long by 8μ in diameter. An individual specimen at this stage of development is 112μ long, 102μ in diameter through the suckers, 42.5μ through the median region, and 52.5μ through the posterior region.

A cysticercoid apparently just beginning to invaginate is 120μ long. Suckers appear to be completely formed, or nearly so, but the rostellum is not completely developed. *H. cantaniana* evidently belongs to the group of cestodes in which scolex differentiation of the larva is partially but not entirely completed before invagination. Invagination itself occurs rapidly, to judge from the comparatively few larvae observed in the process.

The region of attachment to the main stem elongates as the bud develops into a cysticercoid; it is fragile and breaks or disintegrates easily during observation of fresh material.

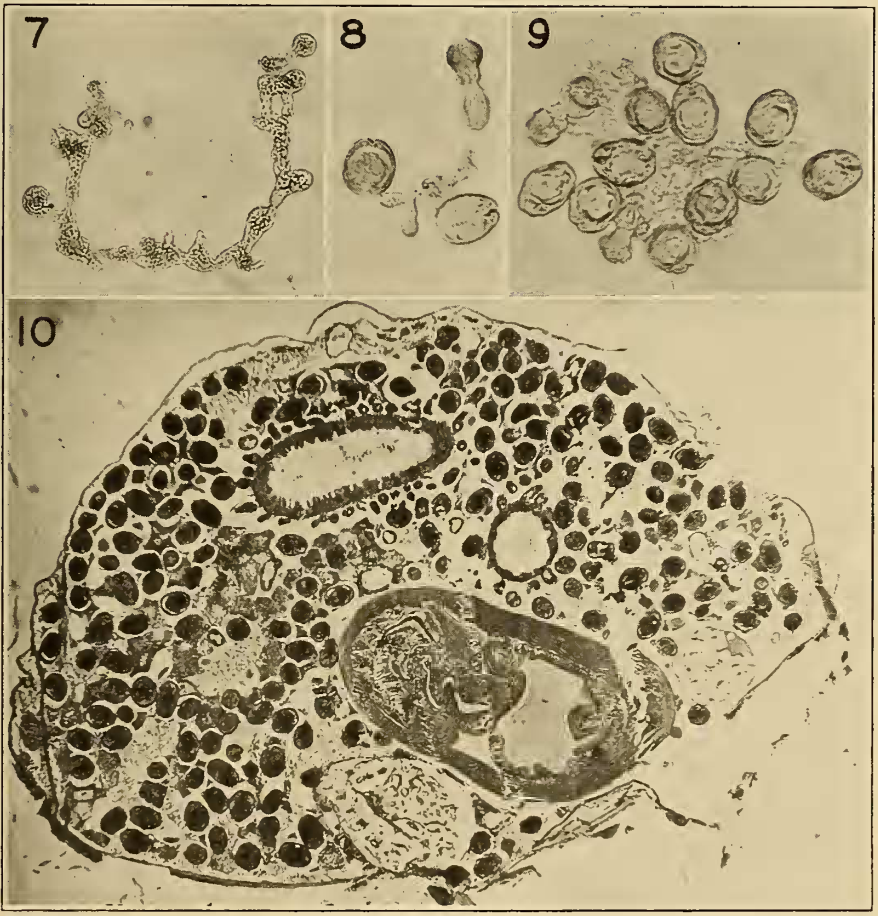
Calcareous corpuscles are first observed in young rounded forms; larvae with one constriction may contain 4 to 10 calcareous corpuscles which, as a rule, are median or distal in position. In completely formed cysticercoids as many as 40 have been counted; these are located in the inner cyst wall and thus are in the neck region of evaginated specimens.

Completely formed cysticercoids or infective larvae (Fig. 6) are spherical or ellipsoidal in shape or, in heavy infestations, may be irregularly compressed. They are comparatively small, 90μ by 68μ to 140μ by 102μ in diameter. The cyst wall consists of a thin cuticula, an inconspicuous basal membrane and sub-cuticular layer, a fibrous zone with irregular spaces representing the old "primitive cavity," and the inner cuticula. The scolex, lying in a small invagination cavity, is about 50 to 72μ in diameter; suckers are 20 to 26μ in diameter, the rostellum is about 22 to 24μ long, only the small rosteller cavity being easily observed in most material. No hooks could be seen on the scolex, although wrinkles of the cuticular lining of the rostellar cavity suggested minute hooks in certain specimens.

Completely formed cysticercoids may remain attached to the proliferating larval tissue by short stems or may lie free in the body cavity of freshly dissected beetles. Although cysticercoids become detached readily during the examination of the material, they do not evaginate readily in tap water, even when stimulated by tapping or heating the slide. Cysticercoids of *H. cantaniana* differ in this respect from those of *H. carioca* or *Raillietina cesticillus,* which evaginate much more readily.

On the basis of the limited material derived from experimental infections of beetles, it is concluded that at room temperature during mid-summer, in Washington, D. C., 11 to 14 days, as a minimum, are required for the cysticercoid to become completely formed. The time necessary for development at lower temperatures is not yet known.

Larval proliferation and development of cysticercoids appear to continue for at least 4 weeks, since in one lot of beetles, collected in mid-October and held so that re-infection was not possible, both completely formed and developmental stages were observed until early in December when the last beetle was killed. However, in some beetles, it has been noted that there were numerous completely formed cysticercoids (Fig. 9) along the branching structures, but only very few developing forms; this might be interpreted as indicating that there is a limit to the period of proliferation of the larva. Surprisingly large numbers of cysts may be found in a single beetle (Fig. 10). As reported previously, the number of cysticercoids counted in one beetle



Figs. 7–9.—Larvae of *Hymenolepis cantaniana* from *Ataenius cognatus.* Natural infestations. Fig. 10.—Section through specimen of *A. cognatus* containing numerous larvae of *H. cantaniana.* Natural infestation.

was 1163, and in another individual, 2217; developing cysticercoids were not included in either count.

SEASONAL OCCURRENCE AND DISTRIBUTION OF INTERMEDIATE HOSTS

The dung beetle, *Ataenius cognatus* Leconte, has been collected near Beltsville, Maryland, from April to November, inclusive. According to information supplied by Dr. E. A. Chapin, this species is very common and widely distributed in the United States and is known to occur as far south as Mexico. In the vicinity of Washington, D. C., it may be collected at any time during the year when weather conditions are favorable.

Ataenius stercorator Fab. is believed to occur from Texas to Brazil and more generally in the West Indies. It has also been reported from Madeira.

Choeridium histeroides Weber has been collected in poultry yards near Beltsville, Maryland, but less frequently than *Ataenius cognatus* or *Aphodius granarius*. It is considered as being moderately common in the vicinity of Washington, D. C., and it may be found at any time during the year if the weather is favorable.

Numerous specimens of *Aphodius granarius* and *Onthophagus* spp., which also were collected from poultry yards near Beltsville, have been found consistently negative for larvae of *H. cantaniana*. Of 10 specimens each of *Aphodius granarius* and of *Ataenius cognatus* which were collected at the same time, from the same poultry yard, the specimens of *Aphodius granarius* were negative while 8 of the specimens of *Ataenius cognatus* contained larvae of *H. cantaniana*. Efforts to infect specimens of *Aphodius granarius* with *H. cantaniana* in the laboratory have been unsuccessful. On the basis of our present information, *Hymenolepis cantaniana* appears to exhibit more specificity as to its intermediate host than do other poultry tapeworms which use beetles in that capacity.

DEVELOPMENT OF HYMENOLEPIS CANTANIANA IN DEFINITIVE HOSTS

Birds were fed larvae from the beetle, *Ataenius cognatus*, as listed in table 1. No cestodes other than *H. cantaniana* were found in any bird and control birds remained free of cestodes.

As noted in table 1, one chick (a), which was examined 11 days after experimental feeding with *H. cantaniana* larvae, contained immature specimens of *H. cantaniana* about 3.5 mm. long. Chick G7068 passed eggs of *H. cantaniana* 14 days after experimental feeding; chick No. 91 passed eggs in droppings, and chick G7047 contained mature speci-

TABLE 1.—DEVELOPMENT OF HYMENOLEPIS CANTANIANA

HOST	DESIGNATION OF HOST	DATE OF FEEDING	DATE OF AUTOPSY	POST-MORTEM FINDINGS
Chick	1	Oct. 26, 1932	Nov. 2, 1932	Negative
	J3	Oct. 26, 1932	Nov. 14, 1932	About 10 almost mature tapeworms
	a	Oct. 28, 1932	Nov. 8, 1932	About 12 immature tapeworms
	b	Nov. 10, 1932	Dec. 2, 1932	Negative
	91	Nov. 15, 1932	Dec. 7, 1932	Tapeworms present (eggs in feces, Dec. 1)
	G7047	Nov. 16, 1932 (ca. 500 cysts)	Dec. 2, 1932	21 mature tapeworms
	G7068	Nov. 16, 1932 (ca. 230 cysts)	Dec. 20, 1932	44 mature tapeworms (eggs in feces, Nov. 30)
	365	June 19, 1933	Died July 3, 1933	? (Bird decomposed)
	305	July 8, 1933	Aug. 17, 1933	Few mature tapeworms
	310	July 8, 1933	Aug. 17, 1933	Few mature tapeworms
	316	July 8, 1933	Aug. 17, 1933	About 10 tapeworms
	345	July 21, 1933	Oct. 3, 1933	Tapeworms present
	324	Aug. 21, 1933	Sept. 21, 1933	Tapeworms present
	406	Sept. 20, 1933	Nov. 14, 1933	Numerous tapeworms
	407	Sept. 20, 1933	Jan. 4, 1934	Negative
	445	Sept. 20, 1933	Jan. 4, 1934	Negative
	421	Sept. 20, 1933	Mar. 10, 1934	Few tapeworms
Bobwhite quail	219	Aug. 27, 1934	Sept. 28, 1934	About 113 tapeworms
Guinea fowl	294	Aug. 27, 1934	Nov. 20, 1934	About 15 tapeworms

mens of *H. cantaniana*, 16 days after experimental feedings. Chick J3, examined 19 days after experimental feeding, contained specimens with egg-filled segments, but with the eggs apparently still unripe; no eggs or gravid segments were found in the posterior regions of the intestine. It is concluded that the time necessary for development of *H. cantaniana* in its definitive host probably varies from 2 to 3 weeks.

In all, 12 chickens, 1 guinea fowl and 1 bobwhite quail have become infested with *H. cantaniana* after being fed beetles containing proliferating cestode larvae. Four chicks remained negative after being fed and a fifth chick (365), which died, was so decomposed when examined that although no worms were found the negative results are somewhat inconclusive since, had specimens been present, they might well have been disintegrated by the time the bird was examined. It is interesting to note that one bird (421) remained infested from September 20, 1933, to March 10, 1934, a period of about 5½ months. Three birds were fed eggs of *H. cantaniana* in an attempt to demonstrate a direct life cycle, but all three birds remained negative for tapeworms.

MORPHOLOGY OF ADULT

Hymenolepis cantaniana (Polonio, 1860) Ransom, 1909. *Hymenolepis:* Worms up to 2.2 cm. long by 400μ wide. Scolex 120 to 160μ in diameter; suckers unarmed, 60 to 70μ in diameter; rostellum unarmed, 80 to 85μ long by 35μ wide, sac-like, the narrow cavity lined with cuticula sometimes wrinkled and striated in appearance. Genital pores unilateral, anterior to middle of segment margin. Testes 3, 1 aporal, 2 poral, usually arranged in a transverse row, but 1 aporal testis may be anterior and median, or dorsal and median, to other aporal testis; testes obscured rapidly by developing ovary and uterus, and at no time conspicuous in strobila. External seminal vesicle near median line; internal seminal vesicle nearly filling cirrus pouch. Cirrus pouch thin-walled, elongate, 70 to 95μ long, extending nearly to middle of mature, but not of gravid, segments. Vagina ventral to cirrus pouch, expanding into comparatively large oval seminal receptacle, for a time the most prominent structure in the segment. Ovary, when mature, sometimes extending to lateral excretory vessels and to anterior border of segment. Uterus sac-like, eventually filling nearly the whole segment and containing about 10 to 20 eggs. Eggs spherical, 45 to 60μ in diameter; oncosphere 22 to 25μ in diameter; embryonal hooks 13 to 14μ long.

Individual gravid segments or groups of 2 or 3 segments are found occasionally in droppings; however, as a rule, segments disintegrate early and individual eggs are found in the posterior portion of the intestine and in droppings. Embryonal activity has been observed in eggs still present in gravid segments of freshly collected strobilae, in eggs from fresh droppings, and also in eggs kept as long as 6 days in a refrigerator (45° to 50°F.). Embryos are not easily activated on a slide as are those in gravid segments of *Davainea proglottina* and *Raillietina cesticillus.*

Hosts.—Definitive: Galliformes (*Gallus gallus, Meleagris gallopavo, Pavo cristatus, Phasianus colchicus, Colinus virginianus* and *Numida meleagris*). Intermediate: Coleoptera (*Ataenius cognatus, A. stercorator,* and *Choeridium histeroides*).

Location.—Small intestine, usually duodenum of definitive host; body cavity, connective tissue and, less commonly, muscular tissue of intermediate host.

Geographical distribution.—Europe (France, Spain, Italy, Jugo-Slavia and U. S. S. R.), Asia (Japan and Indo-China), South America (Brazil), and North America (United States, including Puerto Rico).

SUMMARY

Early developmental stages of proliferating larvae were obtained from 5 specimens of the beetle, *Ataenius cognatus,* which were dissected at varying periods after having been fed eggs of *Hymenolepis cantaniana.*

The hexacanth embryo was found to develop into a larva of several lobes, the latter elongating to form a somewhat branched, mycelium-like, structure; buds arose along the branches which developed into new branches or directly into cysticercoids containing the unarmed scolex characteristic of the species. Development of the bud into the cysticercoid resembles in general the development of other *Hymenolepis* larvae; the process consists of elongation, slight cavity formation, constriction, differentiation of scolex in most details and in-

vagination of cephalic region, resulting in a rounded cysticercoid. Scolex differentiation of *H. cantaniana* is partially, but not entirely, completed before invagination.

On the basis of the experimental findings, the minimum time required for development of an infective larva in the beetle host is from 11 to 14 days; proliferation of the larva and development of new cysticercoids apparently may continue for at least 4 weeks.

Development of the adult worm in the chicken requires at least 14 days and the time probably varies from 2 to 3 weeks.

Twelve chickens, 1 quail and 1 guinea fowl became infested with *Hymenolepis cantaniana* as a result of feeding branched cestode larvae obtained from naturally infested specimens of the beetle, *Ataenius cognatus*.

The beetles *Choeridium histeroides* and *Ataenius stercorator* are reported as additional intermediate hosts, on the basis of their harboring larvae similar to those found in *Ataenius cognatus* and known to be larvae of *H. cantaniana*.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETY

BOTANICAL SOCIETY

SPECIAL MEETING

A special meeting was held in the auditorium of the Interior Department Building on December 11, President W. W. DIEHL presiding; attendance 80.

Program: F. A. MCCLURE: *A garden of oriental bamboos* (illustrated with lantern).

H. H. BARTLETT, University of Michigan. Professor Bartlett discussed the activities and recommendations of the subcommittee on the reorganization of the National Botanic Garden. He emphasized the fact that the present appropriation for the botanic garden was sufficient to maintain a garden of high professional standards, especially in view of the availability of cooperating agencies in Washington. Under the proposed plan the garden would be administered by a botanist of recognized standing, as Director, under the auspices of the Joint Congressional Committee on the Library. An advisory board of directors with representatives from the Smithsonian Institution, the Department of Agriculture, and various scientific societies would also be appointed.

Following Professor Bartlett's remarks, discussion of the proposed plan ensued, and the Society took formal action approving the reorganization of the National Botanic Garden along the general lines outlined in Professor Bartlett's report. The secretary was directed to notify the Chairman of the Joint Congressional Committee on the Library of the Society's action.

262ND MEETING

The 262nd regular meeting was held in the Assembly Hall of the Cosmos Club, January 8, 1935, President DIEHL presiding; attendance 95. J. E. MCMURTREY was elected to membership.